CEMENT AND LIME MANUFACTURE

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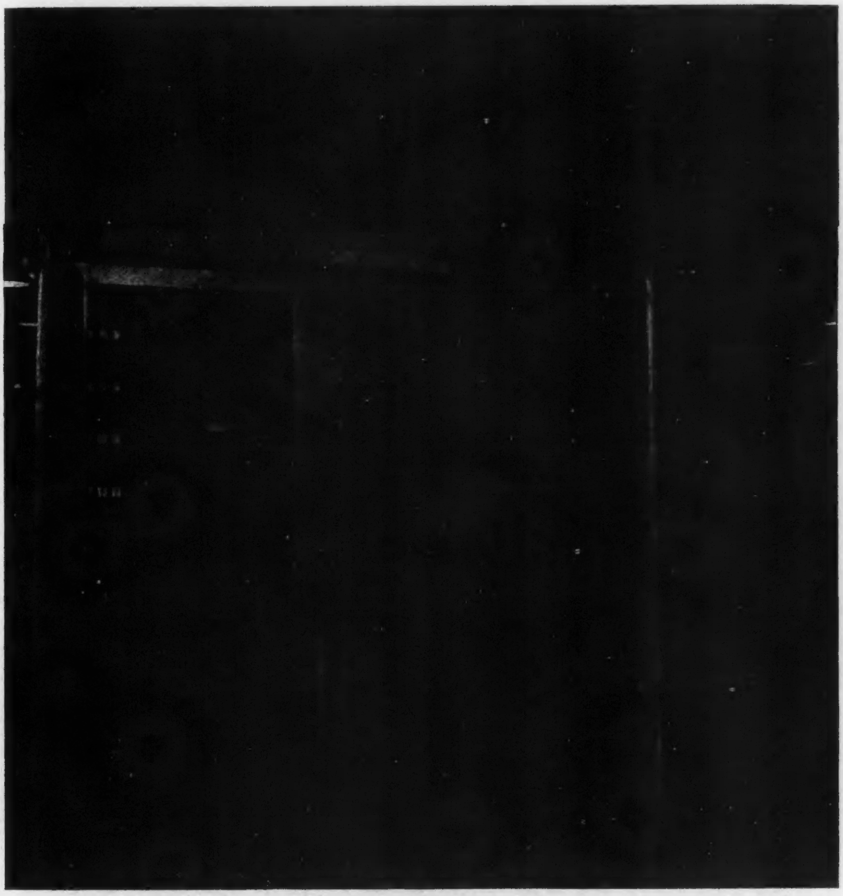
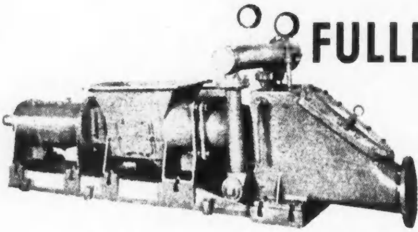


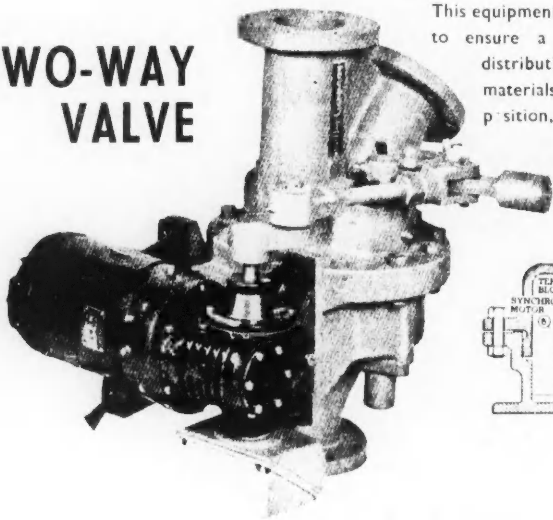
FULLER-KINYON EQUIPMENT



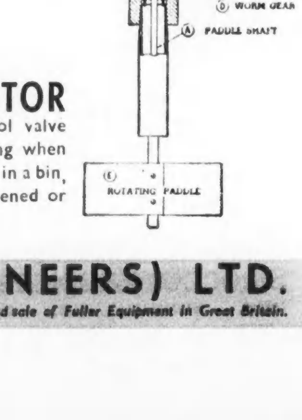
FULLER-KINYON PUMPS

are installed at the new cement works in Ceylon, and represent the most economical and reliable means of transporting finished cement and of blending raw materials. This system is installed in practically all the most modern cement works in the world.

TWO-WAY VALVE



This equipment is also installed at this works to ensure a trouble-free and automatic distribution of cement and raw materials. It can be mounted in any position, and is supplied in a full range of sizes. If required, this valve can be supplied for hand operation.



MATERIAL-LEVEL INDICATOR

This device is employed at this works to control valve circuits, etc., and to give audible or visible warning when material reaches or falls below a predetermined level in a bin, silo, or bunker. One or more circuits may be opened or closed by the same indicator.

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Specifications for Cements and the Trends of Development.

THE VIEWS OF DR. H. KÜHL.

In the course of an article entitled "The Cement of Tomorrow" in "Zement-Kalk-Gips" for May, 1952, Dr. H. Kühl, of Berlin-Lichterfelde, gives his views on the future of cements and of the properties that may be expected to be developed. The following is an abstract of Dr. Kühl's article.

SPECIFICATION TESTS.—Of the many properties demanded of good cement only a few can be standardised and checked, and it may be assumed that cement satisfying those requirements will also be satisfactory as regards its other properties. In current standards there is only one property that is really safeguarded, namely, its hardening properties. The other stipulations are mere props as regards the strength of cement, for none of them is an end in itself; they aim rather at ensuring an undisturbed process of hardening. This applies to the fineness of grinding, the setting time, and the constancy of volume. For example, the tests for constancy of volume allow only for expansion, and no account is taken of shrinkage. It is, however, precisely the reduction of volume that is receiving increasing attention throughout the world. The literature of the subject is full of contradictions, and it has even been held that shrinkage takes place in concrete according to different laws for mortar and neat cement. The shrinkage process of setting cement comprises a chemically determined irreversible and a physically determined (at least partly) reversible process, and is fundamentally always the same, namely, the tendency to form an equilibrium whether or not the cement is mixed with sand. The significance of the shrinkage process on the stability of a structure depends not so much on the appearance of small cracks as on the shrinkage stresses which develop before observable damage has occurred. In Germany the question of shrinkage has been given the attention it deserves in the construction of arterial roads; clauses dealing with shrinkage

are not yet in the standards because there is not yet a perfect method of testing. In the future development of the cement industry the shrinkage properties of cements will play an important part.

There is also an increasing realisation of the importance of the heat generated during setting, and the standards in some countries for low-heat cement indicate a trend towards specialisation. Both aspects of heat generation will have to be taken into consideration, since, according to the temperature and the type of construction, cements will be preferred with either a low or a high heat generation.

In considering the resistance of concrete to climatic conditions, particularly the action of frost, there is a great need for a method of testing which is more related to practical conditions. The laboratory test methods in use do not yield dependable data on the behaviour of cement in a structure.

RESISTANCE TO CHEMICALS.—On the question of the resistance of cement to chemical attack, we have reliable knowledge that the resistance of Portland cements to most chemicals is in inverse proportion to the alumina content. With regard to sulphates it was not seriously doubted since the discovery of the "cement bacillus" in the 1890's that W. Michaelis had solved the problem by replacing the alumina in ore cement by iron oxide or other metal oxides until W. H. McIntire and W. M. Shaw discovered in 1925 that, beside the complex hydrated tricalcium-aluminate sulphate, there is also a complex iron salt of exactly corresponding structure, so that the better resistance to sulphates of ore cement compared with Portland cement containing alumina can now be accounted for by the fact that the ferrite complex salt has a far slower rate of formation than the aluminate salt.

CHEMICAL COMPOSITION.—The American standards for special cements are the most advanced and comprise five types of cement, and give maximum and minimum figures for the composition of the cements in the various classes. These correspond on the whole to practical experience, but they contain a few surprises; for example, there is no cement of the ore-cement type, or even Ferrari cement. The regulations for the chemical composition of the different types of cement are not confined to percentages of the various oxides, but maximum and minimum percentages are also prescribed for the various clinker minerals. To this there would be no objection if there were a simple and accurate method of calculating the mineral constituents of Portland cement clinker by analysis. So long as we have to rely on the mathematical formulae compiled many years ago by Mr. R. H. Bogue under quite different conditions, it must be remembered that the results of the calculation by no means agree with the actual proportions of minerals contained in the clinker. Perhaps it is possible to assume, from experience, that the tricalcium silicate content is always a little higher than that shown by the calculation; on the other hand, the figures for tricalcium aluminate are probably devoid of practical significance, as in all rapidly cooled clinkers alumina is contained to a very high proportion in the residual melt, and the actual tricalcium aluminate content of the cement must therefore always be very much lower than the amount calculated from the analysis. Only if Mr. Bogue's formulæ were replaced by those of Mr. L. A. Dahl would the result have any real significance,

but this is hardly possible due to the extremely complicated nature of Dahl's formulæ and their practical application.

The fact that the Americans are tending more and more to judge cements not by the results of analysis but by their so-called " potential analysis " is particularly surprising, since the American standards state that the calculated content need by no means agree with the actual content of the corresponding clinker minerals. Also Mr. Bogue has pointed out that the properties of Portland cement depend to a large extent on the rate of cooling, and that in particular the aluminate compounds in the residual melt, at the end of the setting process, play a very different part from the proportion of alumina that actually forms tricalcium aluminate. It thus appears that, in spite of the present trend in America, it is to some extent dubious whether the assessment of the composition of the cement from the potential analysis will be maintained in future.

FERRARI AND " NOBLE " CEMENTS.—The American standards do not include Ferrari cements, M. Lossier's expanding cement, and the " noble " cements based on barium and strontium of W. F. Schurawlew and Al. Braniski. Ferrari cements, that is cements containing a high proportion of oxide, combine excellent strength with low-heat generation, low shrinkage, and high chemical resistance. That these properties are very valuable is borne out by experiments on the German arterial roads, where it was found that the formation of cracks was less the higher the iron-oxide content of the cements ; this led R. Dittrich to establish a formula for the correlation between chemical composition and fineness of grinding and the tendency to form cracks. Although further experience is needed before those conclusions can be regarded as confirmed, powerful support will be found for the view that iron oxide cements, not only on account of their low heat generation and high resistance to heat, but also because of their low tendency to shrink, will in future play a considerable part in concrete construction.

W. F. Schurawlew and Al. Braniski have advocated the so-called " noble " cements in which the lime of ordinary Portland cement is partly replaced by barium and strontium oxide. The great resistance to chemical attack attributed to these cements appears to be borne out by investigations by G. Gyarmathy in Roumania. Cements of this kind, owing to the limited occurrence of barium and strontium, will probably always be of secondary importance.

GYPSUM SLAG CEMENT.—In gypsum slag cement the hardening process takes place quite differently from that of Portland cements or blastfurnace cements. M. L. Blondiau has shown that the lime concentration produced on the setting of gypsum slag cements is close to that produced by the hydration of alumina cements, and this has been confirmed by F. Köberich. Gypsum slag cement has high strength, slight tendency to shrink, low heat generation and good chemical resistance. Although it is tempting to attribute the sulphate excitation of blastfurnace slags to the formation of tricalcium aluminate sulphate hydrate, this theory is not adequate for explaining the setting process of gypsum slag cement. Experience teaches that only blastfurnace slags with a high alumina content

respond well to sulphate excitation ; this is related to the question of how high the alumina content must be to form abundantly the complex aluminate sulphate. For the reaction with 12 per cent. to 16 per cent. calcium sulphate, as used in the manufacture of gypsum slag cements, only about 4 per cent. of alumina is needed. Since, however, high-reaction slags often contain 16 per cent. or more of alumina, it is likely that the excess alumina forms free aluminium hydroxide whereby the close contact with alumina cement shown by Blondiau as regards the lime content in the liquid phase is supplemented, and thus makes the high initial hardening understandable.

A New Israeli Standard Specification for Portland Cement.

A NEW standard specification (SI.1 ; 1951) for ordinary and rapid-hardening Portland cement has been issued in Israel. The principal requirements are given in the following.

FINENESS.—The residue on a No. 170 sieve (aperture 0·089 mm.) must not exceed 10 per cent. for ordinary Portland cement and 5 per cent. for rapid-hardening Portland cement. The specific surface is measured by the British Standard method.

SETTING TIME.—The initial setting time must be not less than 45 minutes and the final setting time not more than ten hours.

SOUNDNESS.—The expansion shown by the Le Chatelier apparatus must not exceed 10 mm. The autoclave test is made by the A.S.T.M. method.

STRENGTH.—The tensile tests are made on 1 : 3 mortar specimens in accordance with the method described in British Standard No. 12, and the strengths in kilogrammes per square centimetre must be not less than 20 at three days and 25 at seven days for ordinary Portland cement, and not less than 20 at one day and 30 at three days for rapid-hardening Portland cement.

The crushing strength is tested on 120-mm. cubes of standard concrete comprising specified amounts of fine sand, coarse sand, ¾-in. crushed stone, and 1-in. crushed stone. The strengths in kilogrammes per square centimetre must be not less than 100 at three days and 155 at seven days for ordinary Portland cement, and not less than 100 at one day and 185 at three days for rapid-hardening Portland cement.

CHEMICAL ANALYSIS.—The chemical tests are made in accordance with the A.S.T.M. methods. The insoluble residue must not exceed 1 per cent., the loss on ignition 1 per cent., the content of sulphur trioxide 2¾ per cent., and magnesium oxide 4 per cent. The amount of lime must not exceed $2{\cdot}8\ SiO_2 + 1{\cdot}2\ Al_2O_3 + 0{\cdot}65\ Fe_2O_3$, and must be not less than two-thirds of this amount. The ratio of Fe_2O_3 to alumina must not exceed 1·5.

Electrical Arrangements in Modern Cement Factories Abroad.

By A. D. NEWBURY, M.I.E.E., of Henry Pooley, Consulting Engineers.

Introductory.

It is the purpose of this article to discuss some of the major considerations arising in the design of electrical installations for large modern cement factories generally, and more particularly when required for service abroad. As a means of illustrating the practical application of some of the chief principles involved, a description is given of the electrical installation at a large cement factory recently completed and now in production in Ceylon.

In common with most other industries where heavy machinery is used, it is the practice in the cement industry to make as much use as possible of electrical drives. In a cement factory, even of moderate size, the total power required is comparatively great, and for long periods it is fairly steady. The combination of a large consumption with a good load factor re-acts very favourably on the cost of the electrical equipment in the factory as well as on the cost of the generating plant and mains. There is a correspondingly favourable effect on fuel costs and on the operating and other costs of providing electricity.

These advantageous conditions are present, irrespective of whether the electricity is generated at the factory or purchased from an existing supply. In Great Britain and other industrial countries electricity can generally be purchased at a preferential rate because of the favourable load factor. Although there may be advantages in generating electricity at the works, the convenience and absence of capital cost of purchased electricity are often the deciding considerations. On this account, many British and other owners of cement factories which formerly had their own generating plants now purchase electricity from the public supply. In the case of cement factories abroad, other considerations may also arise, to which reference is made later.

Cement Works in Ceylon.

Shortly after the last war the Government of Ceylon decided to manufacture Portland cement in that country. A study by the consulting engineers resulted in a site for the factory being chosen at Kankesanturai, a small village about 1½ miles from the coast in the Jaffna peninsular at the northern extremity of Ceylon. To enable modern plant to be used, it was essential that the factory, for the production of 100,000 tons of cement annually, should be all-electrically driven and, in the absence of an adequate public supply, a power station at the works was necessary. The power plant is therefore designed to meet the requirements of the factory. Before describing the power station, an outline will be given of the electrical installation in the factory.

Motors.—For the individual drives there are upwards of 130 electric motors, ranging from 800 h.p. for each of the two main grinding mills to a few motors of

2 h.p. or less for driving small auxiliary machines. The largest other single power unit is a 130-h.p. motor for driving the induced-draught fan for the kiln.

To avoid prolonged delay in the event of a breakdown in a distant country like Ceylon, it is important to provide a large stock of all spares, including motors. The cost of an adequate stock of spares in a distant country can thus be high. With this consideration in mind, an endeavour was made to have a minimum range of types, powers, and speeds for all motors, and to make the widest possible use of motors of well-established standard design.

ELECTRICAL SYSTEMS.—For the same reasons it was decided to adopt the British Standard alternating current system of 415 volts, 3-phase, 3-wire, 50-cycles for all motors between 130 h.p. and 1 h.p., as motors for this system are

Fig. 1.—800-h.p. Synchronous Mill Motor.

more readily obtainable from Great Britain. In the case of the two 800-h.p. motors it was considered preferable, in the interests of first cost and electrical efficiency, to arrange these two larger machines for direct operation from the primary extra-high-tension supply at 3300-volts, 3-phase, earthed neutral, 50-cycles.

SPECIAL CONSIDERATIONS.—Although the manufacture of cement is largely a continuous process, it is necessary to provide for wide fluctuations in the loading of motors driving individual machines at every stage of production. This applies to electrically driven cement factories generally, but in particular to factories abroad where highly skilled operators are not easily found. To meet these conditions without risk of damage, some motors have to be of greater power than might otherwise be necessary, and, as these may often operate for long periods at considerably below their normal ratings, the power-factor of the system may suffer with consequent detriment to the efficiency of the installation. This requirement may call for automatic means for power-factor correction. It is also necessary to ensure that if any machines stop due to choking or over-loading there must be no

serious drop in voltage at the motor terminals to delay, or add to the difficulty of, restarting. This calls for adequate generating plant as well as conductors of ample size in all but the shortest feeders and sub-feeder cables.

Further requirements arise from the need to provide for duplicating or otherwise quickly restoring the supply in case of power failure or electrical faults in switchgear or cables, and this applies especially to the kiln, the sudden stopping of which can result in serious and costly damage.

Electrical diagram.—In *Fig.* 3 a single line diagram of the electrical system throughout the factory is given, which shows the types and horse-powers of the motors and their starters and controllers. To facilitate the ready despatch from Great Britain of replacements in response to orders cabled from Ceylon, a sequence system of numbering the various works sections and items is included in the diagram, and is self-explanatory.

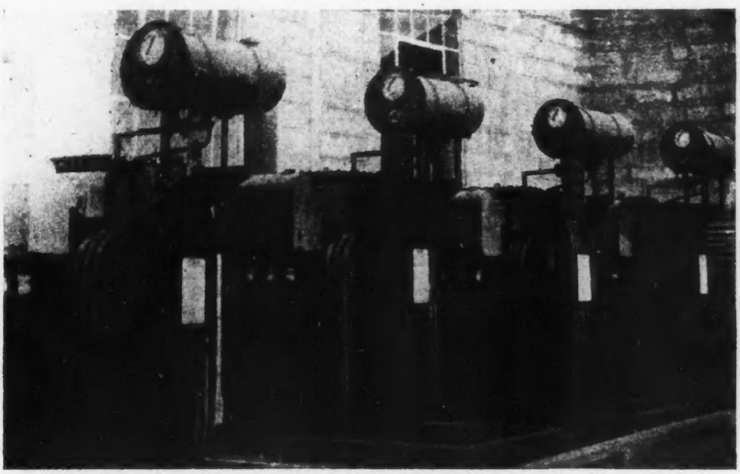


Fig. 2.—500-K.V.A. Outdoor Transformers at Sub-Station.

Incoming E.H.T. supply.—On account of lightning hazard, it was decided to use underground cables for the main E.H.T. transmission from the power station to the factory, because sudden interruption of the main power supply when in full production could cause serious and costly damage to machinery, particularly the kiln. Also, even after restoration of the supply, much time may be lost in clearing chokages, etc., in the plant, and getting the factory into full production again. The main transmission from the power station to the cement factory therefore consists of three separate 0·3 sq. in., 3-core, 3300-volt, P.I.L.C.S.W.A. cables, each about 2200 yd. long, laid in the ground and covered with reinforced concrete marker slabs. Each of the main cables has its own panel on the E.H.T. switchboards in the power station and sub-station, and arrangements on both switchboards ensure

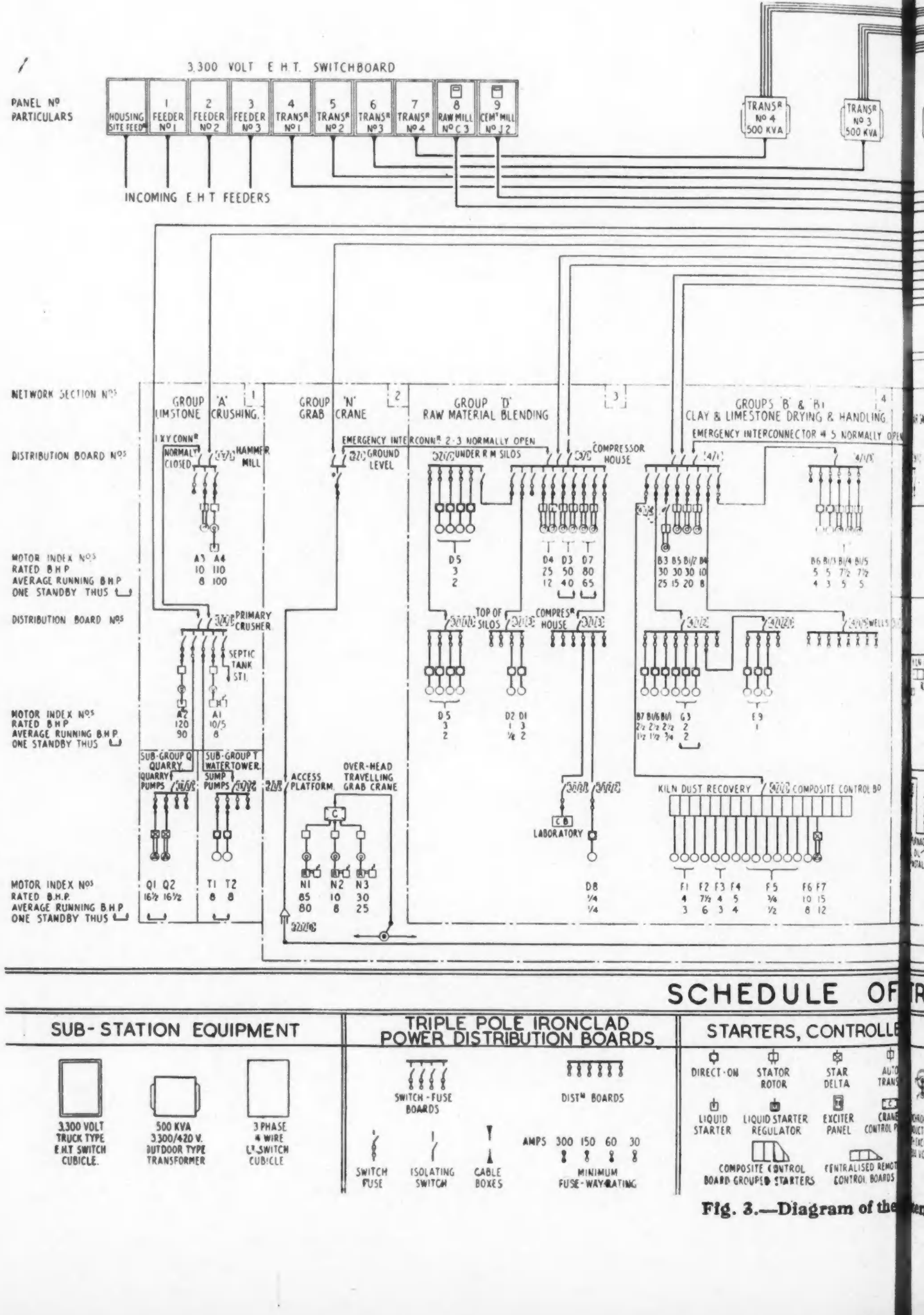
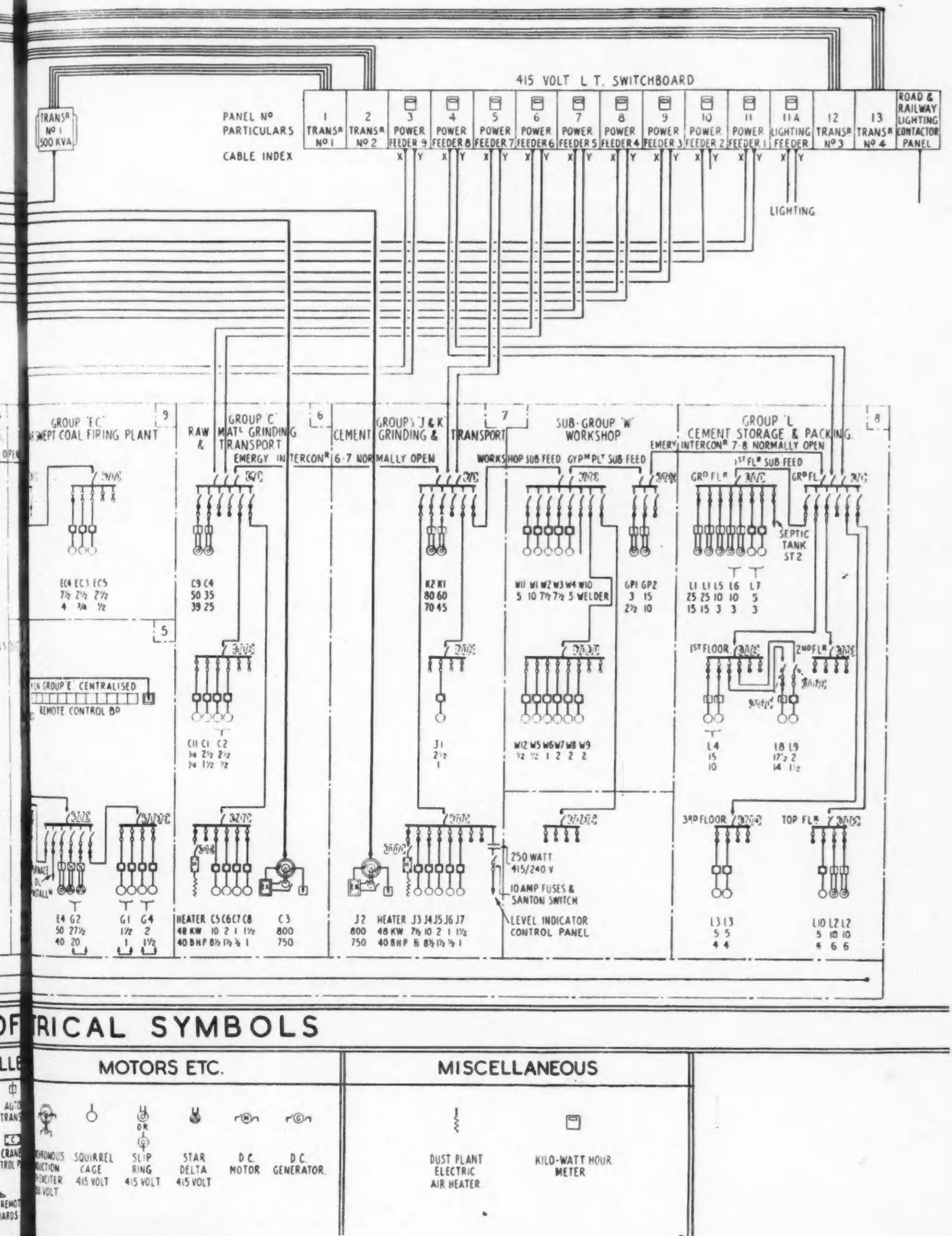


Fig. 3.—Diagram of the



the... em at a Cement Works.

that a fault in any cable will cause its immediate automatic disconnection while leaving the remaining cables undisturbed, thus maintaining an uninterrupted supply.

MAIN SUB-STATION.—It was found convenient to accommodate the large mill motors and the main electrical sub-station equipment together in an annexe to the mill house. A dust-free atmosphere is constantly maintained in this annexe by air filtration and conditioning. The view of the sub-station in *Fig.* 1 shows the main E.H.T. switchboard and one of the two 800-h.p. motors with its reduction gear. An extension of the low-speed shaft of the reduction gear passes through the wall to the pinion driving the girth-gear of the mill.

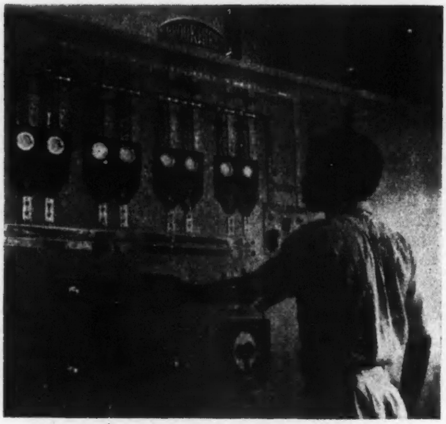


Fig. 4.—Remote-Control Board for Fuller-Kinyon System.

As will be seen from *Fig.* 3, four 500-K.V.A., out-door type, 3-phase, 4-wire, step-down transformers are installed between the E.H.T. and low-tension switchboards for providing a 415-volt 3-phase supply for all motors other than the mill motors, and for 240-volt single-phase lighting. The four out-door transformers are shown in *Fig.* 2. By using two cables in parallel for most of the low-tension feeders advantage has been taken of the higher ratings permissible with smaller cables, particularly where normal ambient temperatures are high. With smaller duplicate cables as the main low-tension feeders there are also further advantages in quickly restoring at least a partial supply by isolating a faulty cable. The work of installing the smaller duplicate cables is also much simpler, especially in restricted spaces. The general arrangement of the twin low-tension feeders is shown in *Fig.* 3 in relation to the main and sub-distribution boards throughout the factory.

POWER-FACTOR CORRECTION.—It will be seen from *Fig.* 3 that the two main 800-h.p., 750-r.p.m., 3300-volt motors (Nos. C3 and J2) are of the synchronous-induction-type with direct-coupled exciters. The exciter-control panels have

special equipment whereby the excitation of the main motors is controlled automatically to suit varying conditions of operation. By this means the main motors, in addition to driving the mills, serve also as synchronous condensers for the automatic correction of the power-factor of the whole installation. Reference has already been made to the undesirable effect on the power factor when ordinary induction motors are running at much below their normal loadings, and the main mill motors thus provide full automatic compensation for the heavy lagging wattless currents resulting from any underloaded motors. By this automatic correction, the overall power-factor of the installation can be constantly maintained at 0·95 lagging, or, if desired, even nearer to unity, with corresponding improvement in efficiency. In view of their important functions for power-factor correction, the advantage of accommodating these large motors in the main sub-station is clear. As the E.H.T. control panels for these two machines are in the main sub-station E.H.T. switchboard, there is a further advantage of very short E.H.T. cable connections to the large motors.

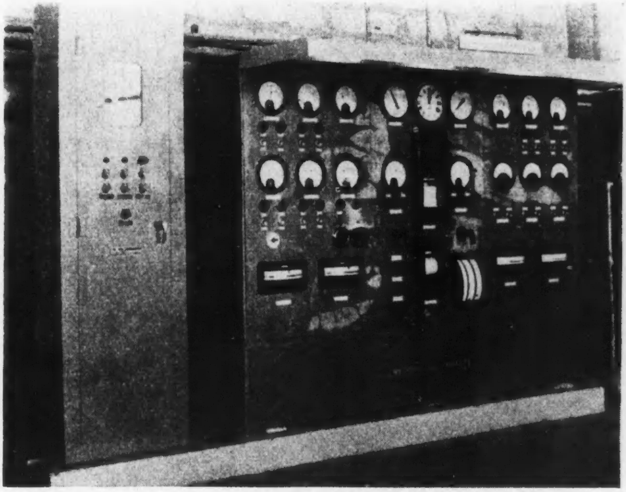


Fig. 5.—Main Kiln-Control Board.

HANDLING AND PREPARATION OF RAW MATERIALS.—It will be seen from *Fig.* 3 that panel No. 11 of the sub-station L.V. switchboard supplies power-feeder No. 1, comprising the twin feeder-cables Nos. 1X and 1Y. These two cables can be interconnected if necessary, and supply the primary and secondary limestone crushing plants respectively.

Handling of the crushed wet limestone and clay to the dryers and the raw mill, and of the clinker from the kiln to the store and thence (with gypsum) to the cement mill, is done by the overhead travelling crane shown diagrammatically in *Fig.* 3 under Group N, Section 2. The electrical arrangements for raw material

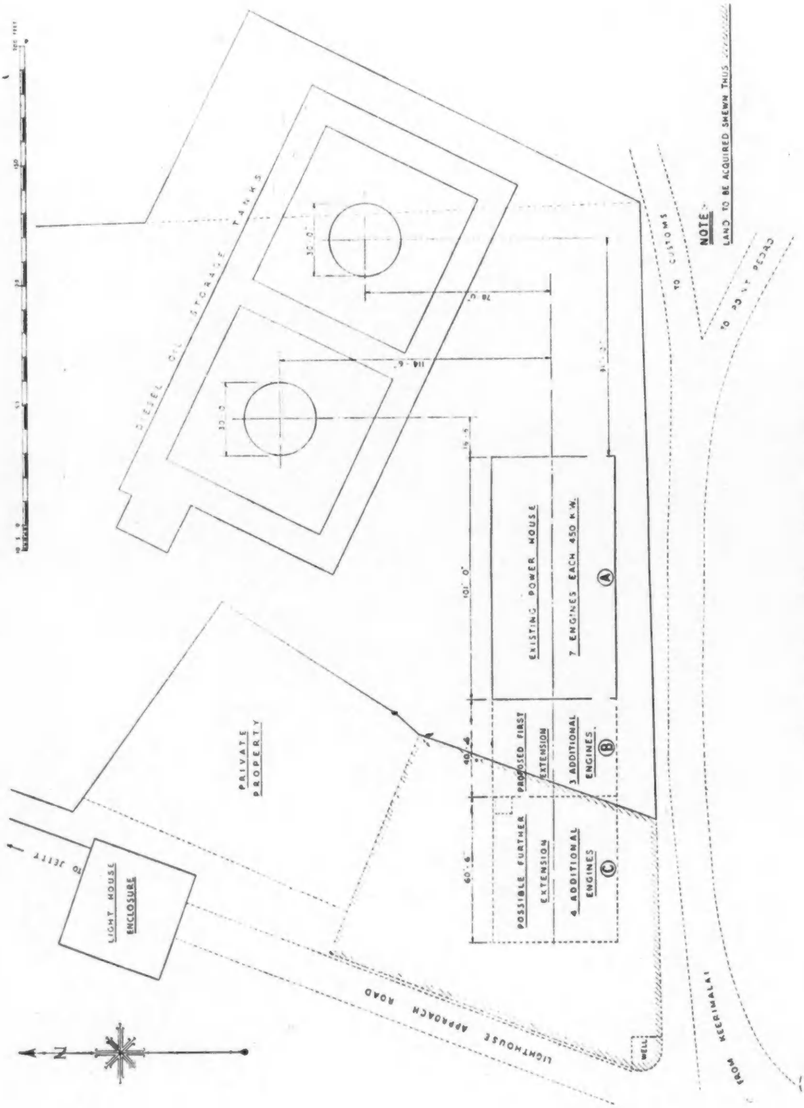


Fig. 6.—Plan of Site of Power Station

drying, etc., under Group B and B1 are shown in Section 4 of the diagram, and for raw-meal transport and blending the electrical arrangements are outlined in Section 3 under Group D.

A point of interest arises under Group D in the use of the Fuller-Kinyon electro-pneumatic system for transporting the raw material by pipeline from the mill to the silos, for circulation and blending between silos, and for final transport of the blended raw meal to the kiln. As a complete description of this system would be out of place here, it may suffice to mention that exact and continuous chemical control of the raw meal blending for the kiln feed can be maintained constantly, and for this reason the main remote-control board (*Fig.* 4) for the Fuller-Kinyon system is in the chemical laboratory.

THE KILN.—The kiln is designed for oil firing, but a complete coal-firing plant is installed as a standby. The electrical arrangements for the kiln when oil fired

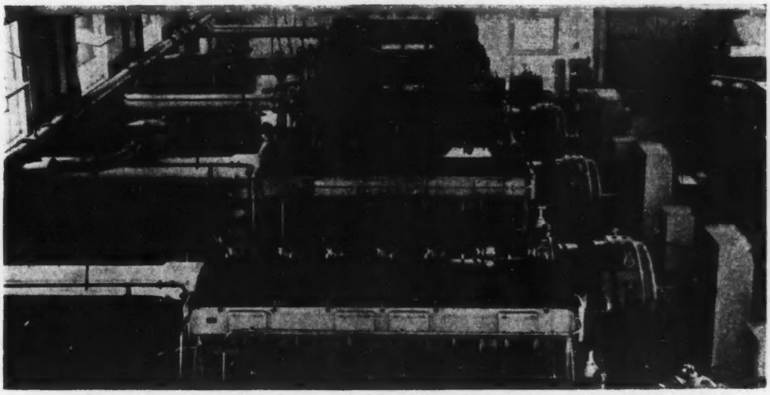


Fig. 7.—Main Diesel Alternators.

are shown diagrammatically in *Fig.* 3 under Group E, Section 5, and for the coal-firing arrangements in Section 9 under Group EC. The kiln is driven through reduction gear by the direct-coupled, 104-h.p., variable-speed, slip-ring motor No. E2, whose speed is controlled by a water-cooled liquid starter-regulator connected in the rotor circuit and mounted on the burning platform. As will be seen in *Fig.* 3, there is a special arrangement for synchronized kiln feed by which, subject to an overriding hand-control for adjustment purposes, the speed of the kiln automatically governs the rate of feed. The many kiln controls are centralized in an electrically operated remote-control board on the burner's platform.

The electrically operated Fuller-Kinyon system is used for automatically controlled air-blast clinker-cooling. In this system a photo-electric cell controls the rate of clinker feed and air blast in relation to the quantity and temperature of hot clinker to be cooled to a temperature suitable for discharge to the conveyors. This equipment is also remotely controlled from the burner's platform. Some of

the remote kiln controls grouped together on the burner's platform are shown in *Fig.* 5, which shows the main kiln control board in the centre, with part of the water-cooled liquid starter-regulator for kiln speed to the right, and the control panel for the Fuller-Kinyon clinker-cooling system on the left.

CEMENT GRINDING, TRANSPORT AND PACKING.—The arrangements for these sections of the plant are shown in *Fig.* 3 under Groups J, K, and L respectively. Reference has been made to the main mill drive by the 800-h.p. motor No. J2, and it may be mentioned that the Fuller-Kinyon pneumatic system is also used for transporting finished cement from this mill to the silos. It will also be noted from *Fig.* 3 that the arrangements for the Groups J, K, and L provide in addition for the electricity required by the gypsum crushing plant and the workshops and stores. There are also embodied in these sections an arrangement of low-voltage interconnectors for use in emergencies, or to facilitate the disconnection of main feeders and switchgear at times of light load or for inspection, cleaning, or repairs.

LIGHTING AND DOMESTIC SUPPLIES.—For general interior lighting a 3-phase, 4-wire ring-main (not shown in detail in *Fig.* 3) is installed. This main encircles the factory and is looped into special main lighting distribution boards at convenient points in the factory, from which supplies are given at 240-volts single-phase to groups of works lighting. The two ends X and Y of this ring lighting-main are fed from panel No. 11A of the main sub-station low-voltage switch-board as shown in *Fig.* 3; the ring-main is normally open but can be closed or opened at any of the main lighting-distribution boards. As there are also quick means for isolating the ends X and Y in panel No. 11A on the sub-station low-voltage main switchboard, this arrangement provides to a large extent for duplication of the lighting supply throughout the factory. For the general lighting of the large buildings a combined system of mercury-vapour and tungsten lamps has been used to provide colour compensation. There is also extensive outdoor lighting of road and railway sidings.

In addition, an underground 3300-volt ring-main, with small transformer kiosks for domestic supplies to the staff residences, has been installed. Thus, although the total lighting load is considerable, it is offset in practice by some reduction of the power demand of the factory at night.

The Power Station.

FUEL AND OTHER PRINCIPAL CONSIDERATIONS.—As already mentioned, the kiln is oil-fired on account of the scarcity of coal in the northern part of Ceylon, and for the same reason it was also decided to adopt diesel-engine driven generating machinery. It was thought that, on account of the humid tropical climate and other local considerations, the following broad general principles should be applied: (1) All the plant must be generously rated, and specially arranged for reliable service under all conditions in Ceylon. (2) Wherever possible standard equipment of the simplest type should be used. (3) Heavy, robust, normal-type engines of low speed would be preferable to faster supercharged engines. (4) A larger number of smaller-sized engines, all with interchangeable spares, would be preferable to a few larger engines. (5) There must be adequate reserve generating capacity to

allow for maintainance and repairs. (6) All working pressures and voltages should be at the lowest possible standard values.

THE SITE.—Although the dry process is not so simple or easily controlled as the wet process of cement manufacture, it requires a much smaller water supply and has a rather better thermal efficiency. Prior to construction of the factory it had been established that a reliable water supply sufficient for a dry-process plant could be obtained locally, but there was at that time some uncertainty whether sufficient water for a wet process plant could be relied upon. The foregoing were among the considerations that resulted in the adoption of the dry process.

Because of the uncertainty of the water supply obtainable in the locality, it was decided to build the power station at the coast, where an adequate supply of sea-water for cooling was assured. While this necessitated cables for the E.H.T.

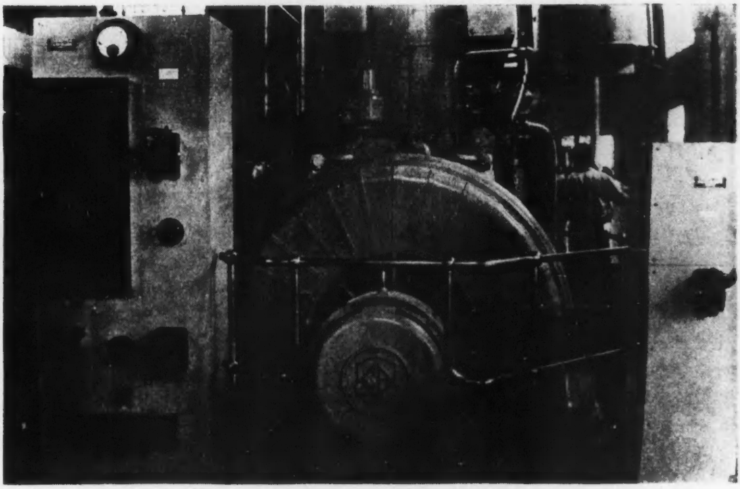


Fig. 8.—No. 1 Alternator.

transmission to the factory, it dispensed with the need for the very efficient air-filtration equipment that would have been required to ensure completely dust-free air for the diesel engines if these had been installed close to the factory. A further advantage of the site on the coast is that it is intended to provide moorings for ocean-going tankers, and a submarine pipeline to enable them to pump oil direct to tanks at the power station and to the factory. As at present fuel oil is railed by tank wagons from Colombo, this scheme should result in very substantial reduction of fuel costs. *Fig.* 6 is a plan of the power station site, and main oil tanks, etc., in relation to the old jetty at Kankesanturai.

GENERATING MACHINERY.—To meet the requirements of the factory as originally planned, it was estimated that the power station would have to meet a total load of about 2200 k.w., and supply between 10 and 11 million units annually.

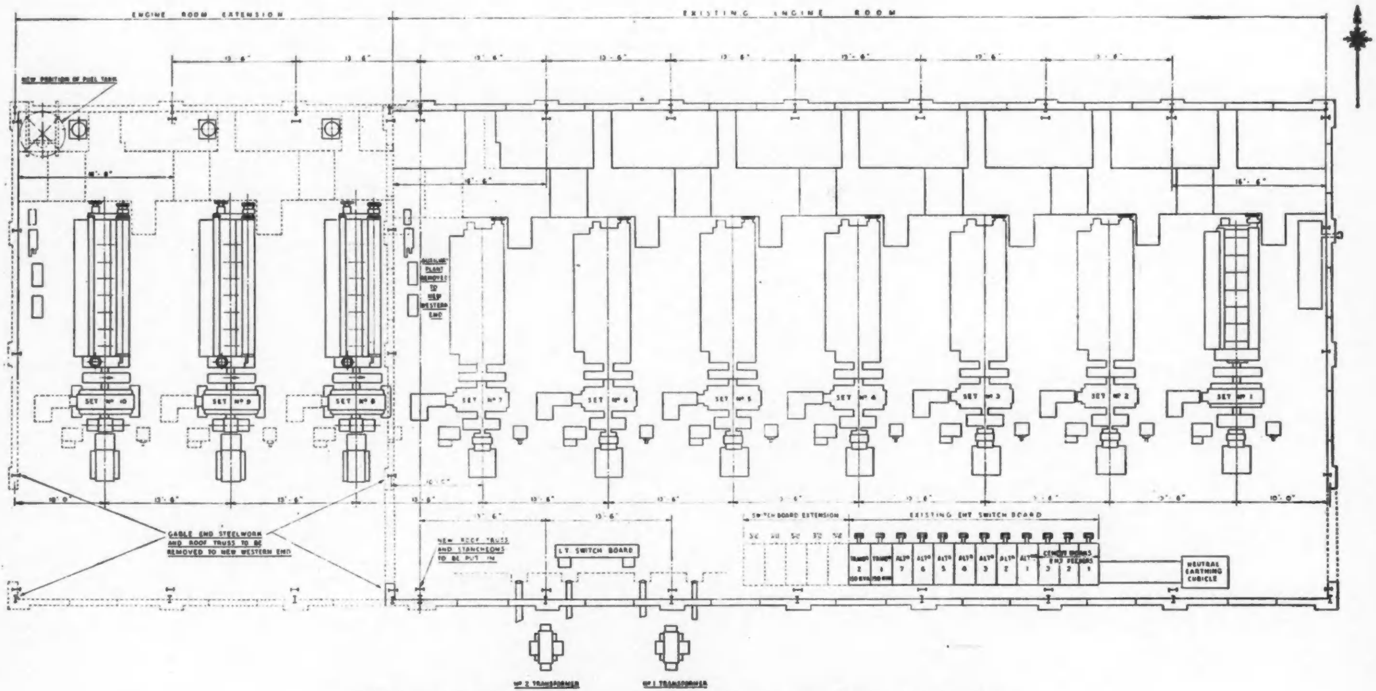


Fig. 9.—General Arrangement of Main Power-Station and Extension.

From the considerations already mentioned, it was thought that five generating sets should be provided to share this load, with one similar set in reserve. An order for the supply and erection of the generating plant was placed with Messrs. Mirrlees, Bickerton & Day, Ltd. (members of Associated British Oil Engines, Export, Ltd.), as main contractors, in association with Messrs. Crompton Parkinson, Ltd., as sub-contractors for the alternators and power station electrical equipment and lighting.

The original part of the power station was therefore designed to accommodate seven Mirrlees standard H.F. type, seven-cylinder diesel engines, each with a normal rating of 770 h.p. at 375 r.p.m., and each direct-coupled to a 3300-volt, 3-phase Crompton Parkinson alternator, continuously rated for an output of 450 k.w. at 0·8 power factor, that is 563 k.v.a. under actual conditions. It was originally estimated that five such engines would meet the normal demand, with a sixth in reserve, and the original order therefore was for six engines. Shortly after the first order was placed, a demand arose for outgoing electrical supplies other than for the cement factory, and an order for a seventh engine was placed thus absorbing all the accommodation that the original part of the power station provides. Further requirements for outgoing supplies have followed, and an extension of the original power station has therefore become necessary for the accommodation of an eighth and larger engine, to which reference will be made later.

The original seven engines are in a building about 100 ft. long by 50 ft. wide internally, of precast concrete block construction. The silencers and the exhaust pipes are on the side of the building facing the sea, together with the overhead three-compartment sea-water tank for primary cooling of the engines.

ENGINE COOLING.—The sea-water tank is supplied from a pumphouse constructed out at sea, and connected to the shore by a walk-way which also carries the pipelines and cables. The pumphouse is equipped with three electrically driven 6-in. vertical-spindle centrifugal pumps set at a level which ensures that they are immersed at the lowest tides. This arrangement was adopted as the pumphouse is normally unattended, and the motors are remotely controlled from the power station; it was considered important that the pumps should be kept constantly immersed to ensure their immediate response to remote starting.

To avoid possible corrosion by the use of sea-water for the engine water spaces, an arrangement of secondary cooling by means of Serck heat-exchangers is installed. With this system, rain-water is pumped in closed circuit through the engine water jackets to the Serck coolers and back to the jackets again, and the heat-exchangers are cooled by the primary cold sea-water.

Other mechanical arrangements in this power station are stream-line filters for the engine lubricating oil, De Laval fuel-oil purifiers, oil-fuel transfer pumps, and diesel-driven and electrically driven compressors and receivers for providing compressed air for starting the main engines.

ELECTRICAL EQUIPMENT.—The main E.H.T. switch board is of Crompton Parkinson's DA 2 truck type and comprises seven panels for control of the 450-k.w. alternators, three panels for the outgoing feeders to the factory, and two outgoing

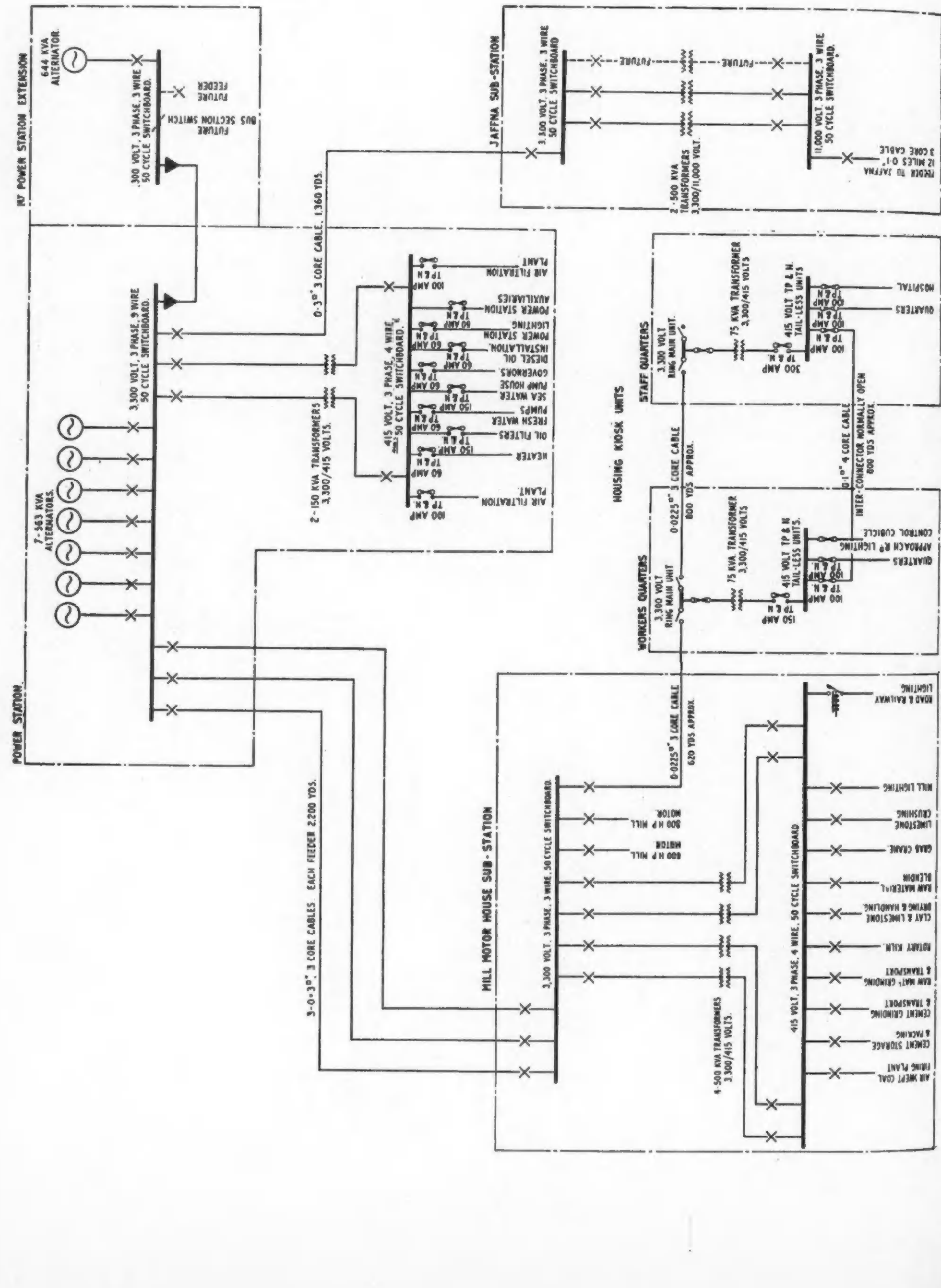


Fig. 10.—Simplified Diagram of the Electrical System.

feeders for two 150-k.v.a. step-down transformers for the low-voltage supply for the power station auxiliaries. It has been necessary to add a further outgoing feeder-panel for the provision of a bulk E.H.T. supply.

Each alternator is provided with its own field suppressor and excitor-control cubicle, on the latter of which is mounted a Tirrel automatic voltage-regulator for each machine. The power station also has its own low-voltage switchboard supplied at 415 volts by the two 150-k.v.a. house transformers for controlling the outgoing supply for the power station auxiliary machinery and lighting.

Fig. 7 shows the internal arrangement of the power station with five of the generating sets, and *Fig.* 8 shows one of the Crompton Parkinson alternators with its excitor and field-suppressor cubicles.

OUTGOING SUPPLIES.—There has been for some years a small public electric supply system in the town of Jaffna, about twelve miles from Kankesanturai. With the establishment of the larger power station at Kankesanturai it was requested that a bulk supply should be given from there to augment the Jaffna supply, as the first step in the development of an electric supply system in the northern part of Ceylon. To meet this requirement it was decided, on account of lightning and other hazards, to use an underground cable at 11,000 volts for the main transmission line. A sub-station was therefore constructed near the cement factory for the purpose of stepping-up the generating pressure of 3300 volts to 11,000 volts. This additional demand necessitated provision of a seventh engine, which completed the equipment of the original part of the power station, and an eighth engine contained in an extension to the original power station has since been added. To maintain complete interchangeability of spares between the eighth and earlier engines, a Mirrlees standard HF type engine at 375 r.p.m., but with eight instead of seven cylinders, has been installed. A rather larger Crompton Parkinson alternator with a continuous site rating of 515 k.w. at 0·8 power factor, that is 645 k.v.a., is directly coupled to engine No. 8.

In *Fig.* 9 the general arrangement of the power station, including the new extension and engine No. 8, is given, and it is seen that the extension has been designed for the addition of two further 515-k.w. sets similar to machine No. 8.

In *Fig.* 10 a comprehensive simplified electrical diagram outlines the whole electrical system, including the power station and its extension, the cement factory and supplies to staff residences, and also the arrangements for the 11,000 volt bulk supply to Jaffna.

This factory was put into commission in August, 1950, and has since been in regular service. Engine No. 8 and the equipment and cables for the bulk supply to Jaffna have been added since the cement factory started production.

The principal contractors concerned in the supply of the equipment were the following: Bousteds, Ltd., Colombo (Electrical installation at power station and factory as agents for Crompton Parkinson, Ltd.). Messrs. Crompton Parkinson, Ltd. (switch-gear, cables, distribution equipment and lighting for cement factory. Transformers, etc., for outside distribution; main feeder cables and switch-gear for supply to Jaffna). The English Electric Co., Ltd. (transformers for supply to Jaffna). Metropolitan-Vickers Electrical Co., Ltd. (main sub-station transformers; motors and starters

throughout the cement factory). Messrs. Mirrlees Bickerton & Day Ltd., and Messrs. Crompton Parkinson, Ltd. (power station machinery). Messrs. Herbert Morris, Ltd. (power station crane). Messrs. William Niel & Son, Ltd. (oil tank and installations). Messrs. Rubery Owen, Ltd. (structural steelwork for power station). Messrs. Tileman & Co., Ltd. (sea-water pumphouse and tanks). Messrs. Vickers-Armstrongs, Ltd. (cement-making machinery). Visco, Ltd. (power station ventilation). All the works described were carried out to the design and under the supervision of Messrs. Henry Pooley, of Westminster, London, S.W.1, consulting engineers to the Government of Ceylon for the construction of the cement factory. Acknowledgments are due to Messrs. Crompton Parkinson, Ltd., for permission to use *Figs.* 1, 2, 4, 5, and 8, and to Mr. R. J. Kimber, of Messrs. Crompton Parkinson, Ltd., for assistance in preparing the electrical diagrams in Figs. 3 and 10. For permission to use *Fig.* 7 acknowledgment is due to Messrs. Mirrlees, Bickerton & Day, Ltd., and to the editor of "The Oil Engine."

New Cement Plant for Venezuela.

THE Venezuelan Development Corporation has guaranteed a loan of four million U.S.A. dollars, granted by the Export-Import Bank, to C. A. Venezolana de Cementos for the purchase of new machinery and spare parts and also a vessel for the bulk transport of cement. It is stated that when the new plant is installed the daily output of this Company will rise from 34,780 to 48,880 sacks.

Cement Production in Venezuela.

THE production of cement in Venezuela in the year 1951 was 621,491 metric tons, compared with 115,784 tons in 1945.

The Cement Industry in French Morocco.

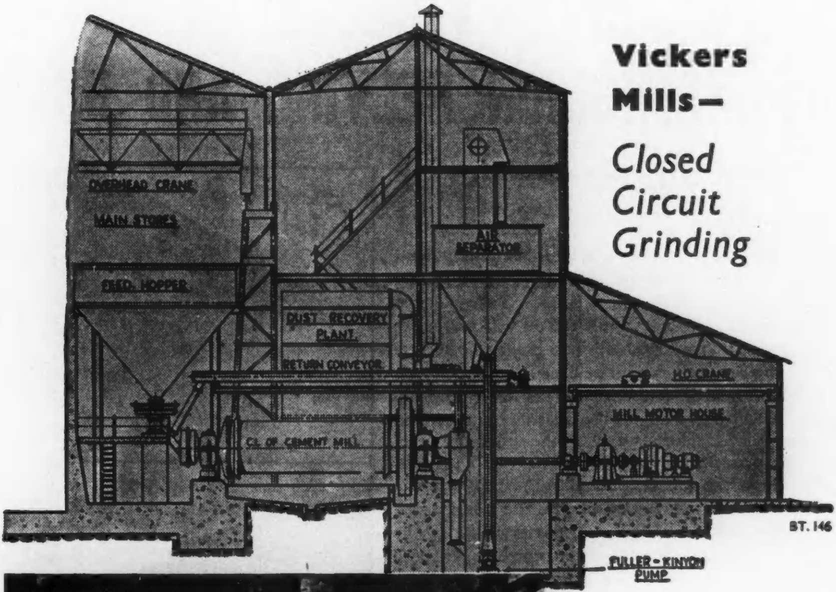
THE consumption of cement in French Morocco in the year 1951 was 715,000 tons, whereas production was 377,000 tons. It is expected that a new factory at Meknes, with a capacity of 130,000 tons a year, will start production in the year 1953, and a new plant at Agadir with a capacity of 50,000 tons a year is expected to be in production at the end of 1952.

The Cement Industry in Sweden.

THE extension of the works at Limhamn of Skanska Cement by the addition of a third rotary kiln is now completed, and another kiln is now being installed at the Hallekis works. These two kilns will have a capacity of 300,000 tons a year.

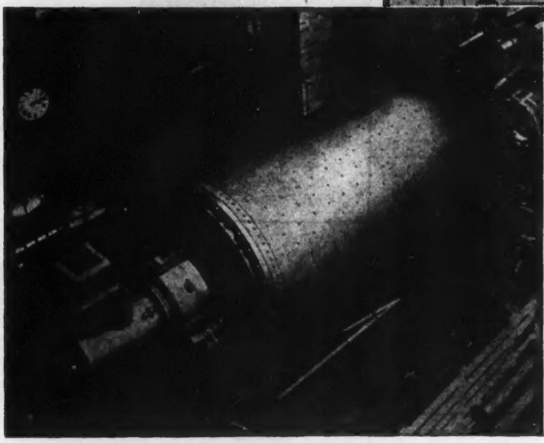
Cement Production in Brazil.

THE production of cement in Brazil in the year 1951 was 2,100,000 tons, and 650,000 tons of cement were imported during the year.



Vickers Mills—

Closed Circuit Grinding



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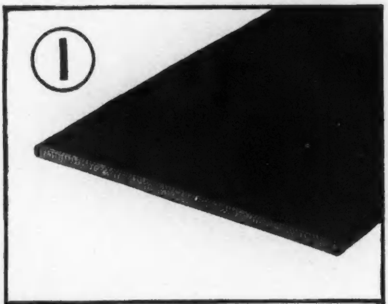

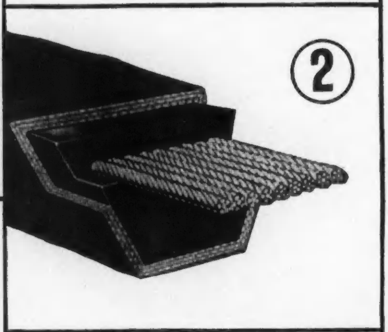

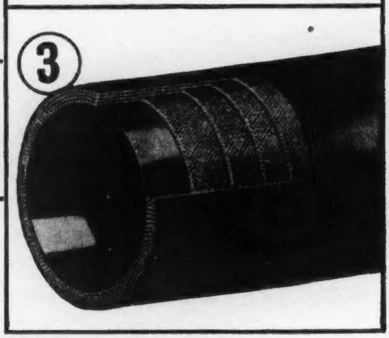

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Closely woven, hard twist duck provides greatly increased power transmission and improved fastener-holding qualities. Folded fabric edges give protection against moisture penetration and edge-wear. A double coating of rubber between plies makes this flexible, tough and thoroughly dependable belt ideal for heavy, continuous work under any condition.

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Japanese Research on Cement.

AT the sixth annual convention of the Japanese Cement Engineering Association, held in Tokyo from May 9 to 16, 1952, eighty-four reports were presented on the chemistry and manufacture of Portland and other cements. The following abstracts of some of the reports have been made in the English language by Dr. K. Koyanagi, the Director of the Association.

FINENESS OF RAW MATERIALS AND STRENGTH OF CEMENT. By K. Watanabe and M. Kajii.—The authors prepared various raw mixtures with different ratios of specific surface area of clay to limestone which were burnt at 1450, 1500 and 1550 deg. C. They found that ratios of 1:2 to 1:4 were the most efficient and economical for producing high-strength cement, and the results agreed very well with those obtained by Jander's formula.

EFFECT OF CHEMICAL COMPOSITION AND FINENESS ON THE WEATHERING OF CEMENT. By K. Watanabe and N. Tanaka.—The authors found that cement containing much C_3S and C_4AF showed greatest resistance to weathering, and that the more C_3A the cement contained the quicker the strength decreased when exposed to the weather owing to the increase of CO_2 content in the cement. At early ages finely-ground cement showed a greater decrease in strength, while after a longer period of weathering coarser cement decreased in strength more quickly.

BLASTFURNACE SLAG CEMENT. By T. Yamanouchi, T. Mohir, and H. Togai.—The authors reported in 1950 that the hydration products of granulated slag with lime after one month's curing were $4CaO.Al_2O_3.12-13H_2O$, $3CaO.Al_2O_3.6H_2O$, $3CaO.Al_2O_3.8-10.5H_2O$, and silica gel. The same samples, after having been stored for one year at room atmosphere, were examined by microscope and X-ray and found to be free from $4CaO.Al_2O_3.12-13H_2O$. From this the authors suggest that the following reaction occurred: $4CaO.Al_2O_3.12-13H_2O+CO_2=3CaO.Al_2O_3.6H_2O-CaCO_3+H_2O$. The authors are of opinion that this property of the surface of hardened slag cement is due to the absorption of CO_2, which causes the chemical reaction given, and reduces the strength of the cement.

SETTING OF CEMENT. By R. Naito.—A study of the setting of cements stored in atmospheres of various humidities and temperatures showed that there was quick setting when the cement was subjected to dry CO_2, while storage in moist air free from CO_2 resulted in slow setting. The addition of alkali carbonate in small quantities such as 0·1 per cent. Na_2O caused abnormal setting, while a greater addition, such as 0·3 per cent., caused quick setting; however, when the quick-setting cement was stored in moist air for 24 hours it became again slow setting. At high temperature, such as 35 deg. C., cement low in gypsum content showed quick setting during storage, but this could be corrected by the addition of more gypsum. At temperatures of 20 deg. C. and 10 deg. C., cement with high gypsum content often had " false " setting properties.

COMPOSITION OF SLAG CEMENTS. By T. Yamanouchi and K. Kondo—Tests made to ascertain the most suitable compositions of Portland cement clinker

and slag in the production of slag cement showed that the following mixtures gave the best results: (1) Portland blastfurnace cement comprising 50 per cent. slag, 47 per cent. clinker, and 3 per cent. raw gypsum; composition of slag: 37 to 48 per cent. SiO_2, 72 to 63 per cent. CaO-Al_2O_3. (2) Gypsum-slag cement comprising 82·5 per cent. slag, 5 per cent. clinker, and 12·5 per cent. calcined gypsum; composition of slag: 58 to 48 per cent. CaO, more than 14 per cent. Al_2O_3. (3) Gypsum-slag cement comprising 75 per cent. slag, 12·5 per cent. $Ca(OH)_2$, and 12·5 per cent. calcined gypsum; composition of slag: near to $2CaO.Al_2O_3.SiO_2$. (4) Lime-slag cement comprising 85 per cent. slag and 15 per cent. $CA(OH)_2$; slag with a chemical composition between $3CaO.2SiO_2$ and $CaO.2Al_2O_3$.

BURNING OF CEMENT. By M. Ueda.—The chemical reaction supposed to be caused by each thermal change was examined by chemical, microscopical, and X-ray methods. The following five typical thermal changes were noted: (1) Endothermal at 800 deg. C. caused by decomposition of $CaCO_3$; (2) Exothermal at 1200 deg. C. supposed to be caused by the formation of $2CaO.SiO_2$; (3) Exothermal at 1280 deg. C. where the formation of $3CaO.SiO_2$ and first liquid phase begins (4 CaOAl $O_2.Fe_2O_3$ is also supposed to be formed at this temperature, but this is not confirmed); (4) Exothermal at 1380 deg. C.; this change is variable in form with raw mixtures of different chemical composition and is supposed to be caused by the formation of the liquid phase; (5) Endothermal at 1420 deg. C., supposed to be caused by the transition from $\beta 2CaO.SiO_2$ to $\alpha 2CaO.SiO_2$.

DETERMINATION OF SO_3. By Y.Ohno.—A method is described of determining the SO_3-content of cement by centrifugal separation of $BaSO_4$, using a separating tube as shown in *Fig.* 1. The method consists of the following operations. (1) Dis-

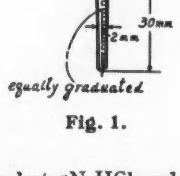

Fig. 1.

solve 0·3 to 0·4 gr. of cement in hot 5N HCl and filter it; (2) To the filtrate, add 7 cc. of 4 per cent. $BaCl_2$ solution in the separating tube; (3) Separate the precipitate of barium sulphate in a centrifugal machine at 3000 revolutions per minute for one minute The height of the sediment in the graduated part of the tube, multiplied by a factor, gives the percentage of SO_3. The time necessary for the

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Situations Wanted, 3d. a word; minimum 7s. 6d. Situations Vacant, 4d. a word; minimum 10s. Box number 1s. extra. The engagement of persons answering these advertisement's subject to the notification of Vacancies Order, 1952. Other miscellaneous advertisements, 4d. a word; 10s. minimum. **Advertisements must reach this office by the 5th of the month of publication.**

SITUATION VACANT.—Applications are invited by a large industrial concern owning and operating cement factories in Pakistan for the post of a Works Chief Engineer.

(A) QUALIFICATIONS: (i) University Degree in mechanical or electrical engineering, and (ii) 5 to 10 years' practical experience in engineering concerns of which at least three years should be in a responsible position. Cement works experience preferred.

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Apply in duplicate stating nationality, age, marital status, qualifications, details of experience supported by copies of certificates and testimonials, together with a copy of latest photograph, to Box JL/112, c/o 95 Bishopsgate, London, E.C.2.

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FOUR BELT CONVEYORS, 170ft. 7¼in. length overall, 38ft. 2in. length overall, 32ft. 4in. length overall, 75ft. 7¼in. length overall, complete with 12in. wide rubber belting but without motors; and three slat conveyors, 99ft. 6in. length overall, 49ft. 5in. length overall, 96ft. length overall, complete with 12in. wide wood slats and each conveyor with 3h.p. Croft's electric motor. £3,000 or near offer is required for these conveyors.

The figure given indicates the value we place on these items of plant, but we are prepared to give favourable consideration to any offer which may be submitted for any items. Any further information which may be required can be obtained from Dow-Mac (Plant & Transport), Ltd., Tallington, Stamford, Lincolnshire. Telephone: Peterborough 4501.

determination is about five minutes, and the result is correct enough for mill control. Care must be taken that the crystal size of $BaSO_4$ is not affected by temperature, concentration, or the added barium chloride solution, as this may make the result uncertain.

HEAT OF HYDRATION OF SLAG CEMENTS. By T. Yamanouchi, R. Kondo, and M. Asano.—Three kinds of gypsum-slag cement, made by adding small amounts of Portland cement clinker, $Ca(OH)_2$, and calcined MgO were tested for heat of hydration at 3, 7, 28, and 90 days. The gypsum-slag cement containing Portland cement clinker showed high early strength and high heat of hydration, while those containing MaO, though not high in early strength and heat of hydration, had very high values at later ages. The cement containing $Ca(OH)_2$ had low strength and heat of hydration, even after a long period.

HARDNESS OF CEMENT. By K. Chujo.—The author found that the upper part of test specimens was always harder than the lower part, and that in cement paste during setting and hardening the upper part was softer than the bottom part, although at later ages this relation was reversed. By chemical analysis and thermoanalysis it was found that the upper part of hardened cement had a higher lime content than the lower part.

The Cement Industry in Indo-China.

IT is reported that the rehabilitation at the cement works in North Vietnam (Indo-China) during 1950 and early 1951 has enabled production to be raised considerably and that it should be possible in 1952 to approach the pre-war production rate of 25,000 tons monthly provided security conditions permit the transportation of adequate supplies of limestone from the quarries. The average monthly production during the period was about 19,000 tons, compared with 12,000 tons in 1950. Although cement is normally one of Vietnam's major exports, only small quantities were sent abroad in 1951 (11,000 tons in the first ten months), the bulk of the production being used for defence purposes. When military requirements fall off it is probable that much of the production could be absorbed locally in development projects, particularly as it may be difficult for Vietnam to recapture pre-war markets as most of these have been forced to seek alternative sources of supply.

New Cement Works for Canada.

IT is reported that three Swiss concerns, namely Holderbank Financiere and the Elektro-Watt and Indelec companies, propose to build a cement works in Canada. The capital is said to be three million Canadian dollars, which will be provided by an issue of shares in Switzerland.

Effect of Temperature and Surface Area on Air-entrained Cement.

AN investigation on the effect of temperature and surface area on air-entrained cement has been made by the Master Builders Company, of Cleveland, Ohio, and is described in the Journal of the American Concrete Institute for November 1951. Two series of tests were made at different times at temperatures ranging from 40 deg. F. to 120 deg. F. In one series the concrete contains 423 lb. of cement per cubic yard and in the other 470 lb. of cement per cubic yard. The nominal slump in all cases was 4½ in. Three of the most commonly used air-entraining agents were used.

The differences in air content were in most cases found to be small, but there seemed to be a general trend toward lower air content, predicted on the volume of air at normal temperature (70 deg. F.), with increasing temperature. The behaviour in this respect of the mixtures with no addition and with the three admixtures was similar but the differences were more evident with the admixtures. The compressive strengths were normal, and what would be expected from the mixtures and curing temperatures. When the curing temperatures were normal the effects of either the higher or the lower temperatures of the mixtures were negligible. When the curing temperature was the same as that of the mixture there was a normal reduction in the rate of hardening.

With no addition the differences in air content were small and the trend was not well defined, although there was a general indication that less air was entrained with increasing surface area. With two of the admixtures this tendency was well defined and there was a substantial range in air contents between the lowest and the highest surface areas. The results of the tests of concrete made with cements of different surface areas showed that without addition the differences in entrained air with surface area were negligible. With two of the admixtures there was a definite indication that the amount of air entrained decreased with increasing surface area. There was a general indication that the water-cement ratio for a given consistency increased slightly with increasing surface area, but these differences were very small. Compressive strengths at one day increased with increasing surface area ; this is still true at seven and even at 28 days, though less marked at the later age.

The conclusions reached were as follows : (1) The amount of air entrained, expressed as its volume at standard temperature and pressure, decreases with increasing temperature. The differences in the case of mixtures with no addition are negligible. (2) With increasing surface area of the cement the amount of air entrained by air-entraining agents decreases. Without air-entraining agents there is no significant variation in air content with surface area. (3) For a given cement clinker the early strengths and rate of subsequent gains of strength increase with increasing surface area. (4) The results secured with respect to air entrainment do not differ significantly with the air-entraining agents investigated.